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IS 13066 (1991): Prepreg based on glass woven fabric for electrical applications [ETD 2: Solid Electrical Insulating Materials and Insulation Systems]

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Indian Standard

PREPREG BASED ON GLASS WOVEN FABRIC FOR ELECTRICAL APPLICATIONS — SPECIFICATION

UDC 621·315·615·96 : 678·5/·8·046·361

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BUREAU OF INDIAN STANDARDS
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May 1991 **Price Group 2**

Solid Electrical Insulating Materials Sectional Committee, ETDC 2

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

This standard covers the requirements of prepreg from glass woven fabric for electrical applications.

Thermosetting resin bonded prepreg made from glass fabric reinforcement are superior to those made from cellulosic reinforcement such as paper and cotton fabric. This standard deals with B stage thermosetting resin treated with glass woven fabric. By experience glass fabric based material have better combination of physical, electrical, mechanical and superior thermal properties.

These materials are used for manufacturing insulating components for various end uses in high voltage applications in static and rotating electrical equipments for profiled and non-profiled components. These components can be manufactured by compression moulding under temperature or hot rolling processes. These also be used for filling up gaps in winding overhangs of generators as a conformable material.

Varnished cotton cloth and tapes for electrical purposes are covered by IS 3352 : 1965 'Specification for varnished cotton cloth and tape for electrical purposes' and cellulosic papers for electrical purposes are covered by IS 9335 : 1979 'Cellulosic papers for electrical purposes', IS 10192 : 1962 'Synthetic resin bonded glass fibre (SRBGF) sheets for electrical purposes' and IS 11297 : 1985 'Varnished fabrics for electrical purposes' are the specifications for synthetic resin bonded glass fibre (SRBGF) sheets for electrical purposes and varnished fabics for electrical purposes respectively.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PREPREG BASED ON GLASS WOVEN FABRIC FOR ELECTRICAL APPLICATIONS — SPECIFICATION

1 SCOPE

1.1 This standard covers technical requirements and methods of test (specimen details, etc) for polyester, epoxy, melamine phenolic and silicone treated 'B' stage glass reinforcements.

1.2 Nominal thicknesses covered are:

Thickness of woven glass fabric (mm)	0·10	0·13	0·18	0·25	0·28	0·30
Thickness of prepreg (mm)	0·14	0·17	0·23	0·30	0·34	0·36

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1998 : 1962	Methods of test for thermosetting resin bonded laminated sheets
10192 : 1982	Synthetic resin bonded glass fibre (SRBGF) sheets for electrical purposes

3 CLASSIFICATION

3.1 'B' staged prepregs are broadly classified according to resin used:

a) PF based on phenolic formaldehyde resin system,

b) Unsaturated polyester (imide resin based system) (tolerance on average thickness of prepregs shall be ±10 percent),

c) EP based on epoxide resin system,

d) MF based on melamine formaldehyde resin system, and

e) SP based on silicone resin system.

3.2 Thermal Classification (Temperature Index)

For general guidance, the following resin systems are recommended:

a) Phenolic based for temperature index 140,

b) Modified phenolic based for temperature index 150,

c) Bisphenol 'A' epoxy with appropriate hardener for temperature index 130,

d) Bisphenol 'A' epoxy based with appropriate hardener for temperature index 155,

e) Epoxy novolac with appropriate hardener for temperature index 155,

f) Melamine formaldehyde based for temperature index 140,

g) Unsaturated polyester based for temperature index 130, and

h) Silicone based for temperature index 180.

3.3 Type of glass reinforcement in glass woven fabric.

NOTE — The glass fabric reinforcement shall be made from type 'F' glass containing not more than one percent alkali metal oxide, that is, Na_2O.

3.4 Glass reinforcement prepregs are further classified for different combinations of properties by means of numerical suffixes.

Example:

UPP_1, UPP_2, PFP_1..............., etc.

Details of classification, resin and reinforcements are given in Table 1 for guidance only.

4 GENERAL REQUIREMENTS

4.1 Appearance

Prepregs shall be reasonably smooth and free from visible defects like air bubbles, resin concentration, dry patches, deep scratches or cuts or inclusion of foreign particles. Light coloured lines, spots and wrinkles are, however, permissible in so far as they do not affect the properties and/or performance.

The prepreg should be reasonably flexible and should permit easy unrolling at room temperature resin should not peel off during unrolling.

4.2 Tolerance on average thickness of prepregs shall be within ±10 percent.

4.3 The length and width of prepregs shall be as agreed between the supplier and the buyer.

4.4 The shelf life of 'B' staged prepreg should be minimum 3 months at 20°C and 6 months at 5°C, storage temperature.

4.5 The volatile content, total resin and soluble part of the resin (in appropriate solvent) should be as given in Table 2.

Table 1 Grades of Glass Reinforced Prepregs

(*Clause* 3.4)

Sl No.	Grade.	Resin	Remarks
(1)	(2)	(3)	(4)
1.	PFP$_1$	Phenolic for temperature index 140	—
2.	PFP$_2$	Modified phenolic for temperature index 155	Higher electrical and mechanical properties than those of PEP$_1$
3.	EPP$_1$	Bisphenol 'A' epoxy with appropriate hardener for temperature index 130	—
4.	EPP$_2$	Bisphenol A' epoxy with appropriate hardener for temperature index 155	Higher electrical and mechanical properties than those of EPP$_1$
5.	EPP$_3$	Bisphenol 'A' epoxy with appropriate index 155	Higher electrical and mechanical properties than those of EPP$_2$
		or	
		Epoxy Novalac with appropriate hardener for temperature index 155	—
6.	MEP$_1$	Melamine formaldehyde resin system for temperature index 140	For good arc, flame and tracking resistance
7.	UPP$_1$	Unsaturated polyester resin based system for temperature index 130	—
8.	SP$_1$	Silicone resin based system for temperature index 180	Heat and arc resistance low dielectric loss and high insulation resistance under high humidity

NOTE — Certain special properties of prepregs may be agreed between the supplier and the buyer after adding appropriate additives.

Table 2 Requirements of Resin

(*Clause* 4.5)

Sl No.	Characteristic	Unit	Properties of Prepreg					Test Method
			Glass Epoxy	Glass Phenolic	Glass Melamine	Glass Polyester	Glass Silicone	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Volatile content (maximum)	Percent	0·6	3	6	2	1	As per 5.3
2.	Total resin	Percent	40±2	40±2	42±3	40±2	40±2	As per 5.4
3.	Soluble resin (minimum)	Percent	80	80	80	80	80	As per 5.5
4.	Resin flow	Percent	15-20	18-24	8-12	15-20	3-7	As per 5.6
5.	Tensile shear strength (minimum)	N/mm^2	40	20	8	8	8	As per 5.7

4.6 Laminating Properties (Type Test)

a) The properties of 3 mm thick laminate made from the prepreg should be as per Table 3; and

b) For determination of heat distortion temperature, laminate should be made of 10 mm thick.

5 TEST METHODS

5.1 General Test Conditions

Unless otherwise specified, all tests shall be carried out within a temperature range of 15°C to 35°C and relative humidity range of 45 to 75 percent. Before measurements are made, the specimens shall be preconditioned under these atmospheric conditions for a time sufficient to allow specimens to reach stability.

5.2 Thickness

The thickness of the prepreg should be measured by micrometer having working range 0 to 25 mm and least count 0·01 mm.

5.3 Volatile Content

Specimen of prepreg in size 100×100 mm is weighed and kept in the oven at 105±5°C for 1 hour and then weighed again.

Volatile content is determined by the following formula:

$$V, \text{ percent} = \frac{W_1 - W_2}{W_1} \times 100$$

where

V = content of volatiles in percent,

W_1 = weight of specimen before drying in grams, and

W_2 = weight of specimen after drying in grams.

An average of minimum two readings shall be taken for the final results.

5.4 Total Resin Content

The dry content shall be determined with the help of following formula:

$$A, \text{ percent} = \frac{a_1 - a_2}{a_1} \times 100$$

Table 3 Characteristics of Prepreg

(*Clause* 4.6)

Sl No.	Characteristics	Unit	PFP$_1$	PFP$_2$	EPP$_1$	EPP$_2$	EPP$_3$	MFP$_1$	UPP$_1$	SP$_1$	Method of Test Ref to Cl No. 4(a)
1.	Specific gravity (minimum)	—	1·7	1·7	1·7	1·7	1·7	1·9	1·6	1·7	
2.	Water absorption (maximum)	%	0·4	0·4	0·3	0·3	0·3	1·0	0·6	0·3	12 of IS 1991 : 1962
3.	Tensile strength (minimum)	N/mm^2	90	180	240	240	270	100	140	120	5 of IS 1995 : 1962
4.	Cross breaking strength (minimum)	N/mm^2	150	200	300	320	350	140	160	150	6 of IS 1998 : 1962
5.	Shear strength (minimum)	N/mm^2	90	100	100	100	100	110	55	100	7 of IS 1998 : 1962
6.	Electric-strength Flatwise tested in oil at 90°C, (minimum)	kV/mm	10	12	10	11	12	2·0	8·0	14	13 of IS 1998 : 1962
7.	Insulation resistance	Megaohms	100	500	1 000	2 000	10 000	0·1	500	2 000	15 of IS 1998 : 1962
8.	Comparative tracking index	Volts	100	100	300	300	350	400	300	500	5 of IS 2824 : 1975
9.	Martens heat distortion temperature	°C	200	200	220	240	260	150	120	260	As per Annex E of IS 10192 : 1982

NOTE — When laminating properties are to be determined made out of prepregs EPP$_2$ and EPP$_3$ respectively, retention of cross breaking when determined at 155°C shall be more than 50 percent of the specified value at room temperature.

where

A = content of resin in percent;

a_1 = weight of prepreg of known size after drying at 105 ± 5°C for one hour in grams; and

a_2 = weight of unvarnishes glass cloth of same size, after drying at 105 ± 5C° for 1 hour in grams.

An average of minimum two readings shall be taken for the final results. Specimen size should be 100 × 100 mm.

Alternatively, total resin may be determined on volatile from basis, by heating specimen at 550 ± 50°C for 60 to 90 minutes.

5.5 Soluble Resin (in Relation to Resin)

It may be determined by putting the percent value of soluble resin content (in relation to prepreg) in the formula for the determination of soluble resin (in relation to resin).

In Relation to Prepreg

Specimen of prepreg in size 100 × 100 mm is weighed and soaked in acetone or another suitable solvent for above 15 min subject to the condition of solubility of resin and is rinsed in fresh solvent, dried in air for about half an hour (it is allowed to dry in oven at 70°C to 80°C for about 5 min after an initial drying in air for 10 min).

Thereafter, it should be weighed again.

Soluble resin is determined by following, formula:

$$B = \frac{b_1 - b_2}{b_1} \times 100$$

where

B = content of soluble resin (in relation to prepreg) in percent,

b_1 = weight of specimen in g in initial condition, and

b_2 = weight of specimen in g after rinsing it in solvent and drying as above.

In Relation to Resin

Soluble part of resin (soluble resin in percent in relation to total resin), C is calculated as follows:

$$C = \frac{B}{A} \times 100$$

where

C = soluble resin (in relation to resin) in percent,

B = percent soluble resin (in relation to prepreg), and

A = total resin content.

5.6 Resin Flow

The specimen shall consist of 4 to 6 plies of 100 × 100 mm with the tolerance of ±1 mm and having weight at least 20 g. The test specimen shall be weighed (W_1) and then placed between stainless steel plate with the size of 150 × 150 mm and approximately 1·5 mm thick with the treatment of appropriate type of releasing agent. The assembly shall be located centrally of the heated plates of a press. The pressing schedule (temperature, pressure and pressing time) for the different material shall be followed according to schedule given below. The laminate shall then be removed from the press and a squarish piece of 50×50 mm, in size should be punched or cut from the centre of the laminate produced and weighed (W_2).

The flow of resin (F) from test specimen shall be calculated as follows:

$$F = \frac{W_1 - 4 \times W_2}{W_1} \times 100$$

The flow of the material under test shall be reported as the arithmetic mean of the result of the three samples.

Resin	*Temperature °C*	*Pressure N/mm²*	*Remarks*
Phenolic	160	15	Pressure to be applied within 10 seconds and retain the pressure for 15 minutes
Epoxy	160	30	
Melamine	160	15	
Polyester	120	15	
Silicone	200	30	

5.7 Tensile Shear Strength

Two clean flat copper strips of size 150×25×2 mm are taken. Ends of the strips are kept, with 2 layers of prepreg, 25 mm wide sandwiched in between for an overlap length of 25 mm, PTFE release tape for film wound over the overlaps and strips are secured. The assembly (except for silicone prepreg) is then loaded in the press at room temperature. Then, a specific pressure of 2 N/mm² is applied. The temperature is raised to 150°C within 30 minutes and the samples are maintained under 2 N/mm² specific pressure and temperature of 110°C for 30 minutes.

The condition of temperature and pressure is maintained for two hours. For silicone prepreg sample shall be loaded at 170°C and specific pressure applied 7 N/mm² keep this under temperature and pressure for six hours, then the specimen is cooled under pressure and is released from the press at room temperature. The release tape is removed and the copper strips are cleared of flashed of resin.

Samples are tested for tensile shear strength, which is calculated as follows:

$$\text{Tensile shear strength} = \frac{\text{Breaking load (kg)}}{\text{Area of overlapping (cm}^2\text{)}}$$

5.8 Specific Gravity

Specific gravity shall be determined in accordance with Annex A of IS 10192 : 1982.

5.9 The following tests shall be performed as per IS 1998 : 1962:

a) Water absorption;

b) Tensile strength;

c) Cross breaking strength;

d) Shear strength;

e) Electrical strength flat-wise, tested in oil at 90°C; and

f) Insulation resistance.

6 PACKING AND MARKING

6.1 The individual roll shall be sealed and packed suitably to avoid damage during transit and storage.

6.2 The package shall be marked as follows:

a) Purchase reference;

b) Material description;

c) Thickness, width and roll size;

d) Total quantity in metres × number of rolls;

e) Date of manufacture; and

f) Date of expiry under stipulated storage conditions.

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